Industrial Safety Engineering
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Lecture - 11
Application of Hazard Identification Techniques

Hello, welcome. So, far you have seen many of the concepts and some of the Hazard Identification Techniques. Today I will discuss those concepts and techniques, I can say that you are revisiting some of the things what you have learnt. So, today's topic is application of hazard identification techniques.

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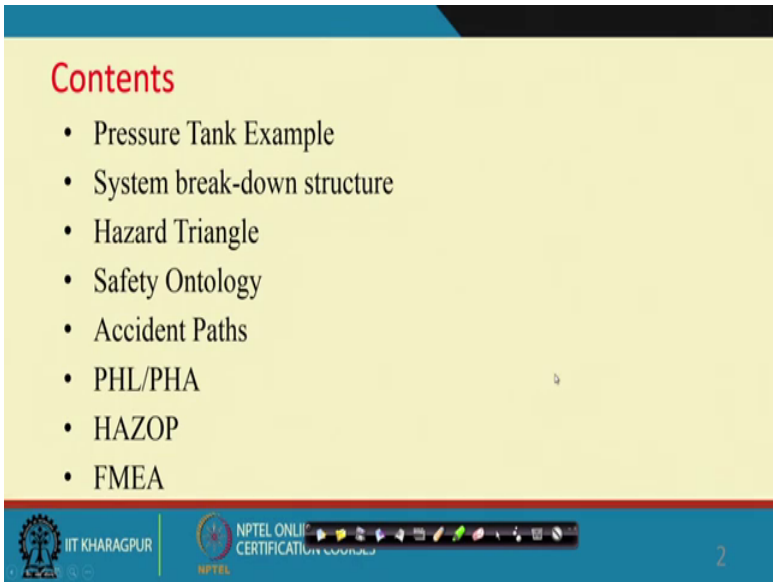

The contents today will be pressure tank example; so, already I have explained what is pressure tank example, that example again we will revisit. Then with reference to that pressure tank system we will show you, we will see that the system breakdown structure particularly its will be hardware base structure

Then hazard triangle, then safety ontology, then after safety ontology from on safety ontology several accident paths can be generated. Then the preliminary hazard list preliminary, hazard analysis HAZOP, FEMA, FMEA all those we reference to pressure tank example. Please note that that it is not the exhaustive explanation, it is rather a; some systematic way of doing hazard identification that is what we will be discussing now.

May be you can find out some more aspects particularly related to hazard identification, but nevertheless this lecture will give you or we will clarify you if you have some doubt earlier with respect to the different concepts.

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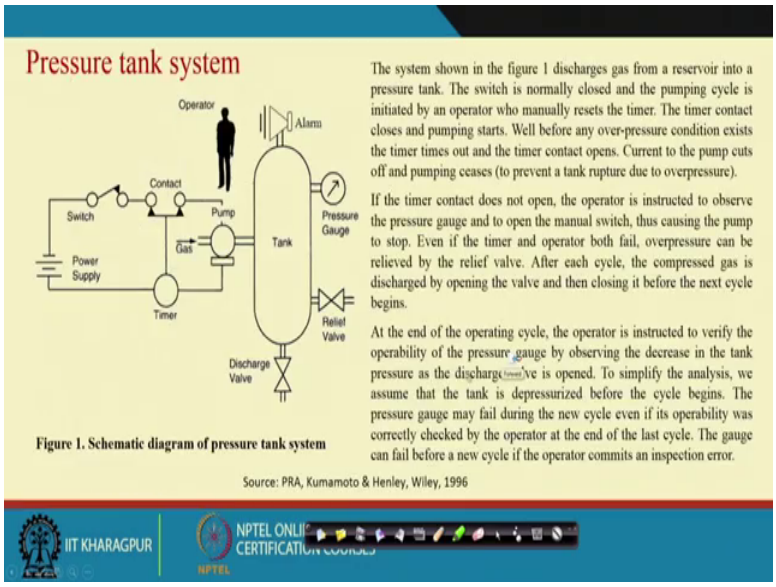

So, I let me repeat it again, this system you know here what happen; one is the tank and the purpose of this tank is to store gas which will be pressurized to certain design intent. And they whether that particular pressure is attained or not or more pressure if it is attained then what will happen so, those things are basically monitored and activated or other way can rectified using alarm, pressure gauge, relief valve as well and operator shelf. But, the tank is pressurised by gas and the gas is pumped to the tank with the help of a pump, which is actuated by another mechanism, which is basically timer and the electrical circuit.

So, this is what is explained here, the cycle begins with 0 gas in the tank and then pumping starts with the timer set to a particular time, the timer is set in such a manner that the desired pressure is attained inside the tank. And after that what will happen timer automatically disconnect the contact and then pump will be disconnected from the power pumps just to operate.

So, after that what happened the distance bulb will open and the gas will go to the utility equipment and that for simplicity that complete discharge is consider. In between what can what are the different things that can happen are one is the timer will fail, maybe that

connect to pump will be more connect electricity to pump will be more than the desired time pump will overrun, pump overrun leads to over pressure, under over pressure condition alarm may work may not work. If alarm work operator may come and see the pressure gauge or may be delayed, so many things can happen which are all negative things or positive things, but mostly we will be concentrating on the negative things. So, this is what we have already discussed and you know this.

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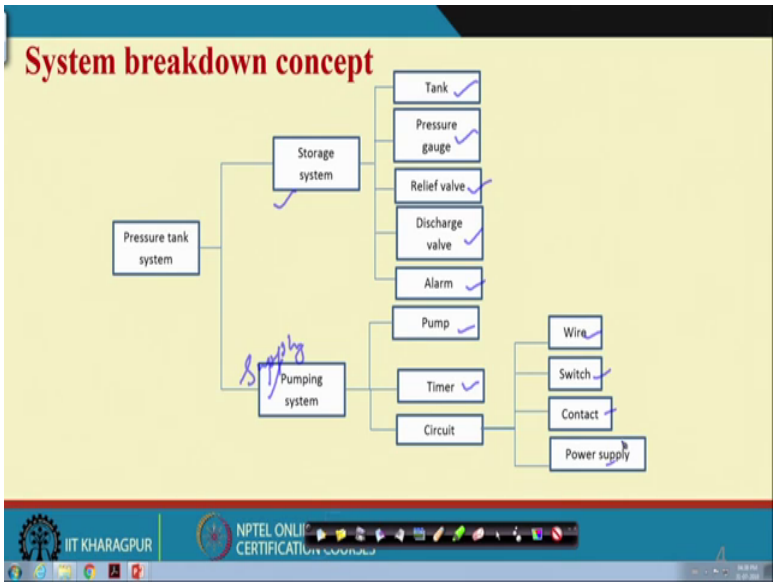

Then with reference to this system what I have done, I said that this pressure tank system as storage system, another one is pumping system or supply system I can say supply of gas. So, then in the storage system pressure tank is one pressure gauge, relief bulb, discharge bulb, along these are the these are the components for the pressure storage system, pumping system: pump is the timer and the electric circuit; obviously, the timer can be within the circuit, but timer is special one. So, we kept it separately and then circuit the wire, switch, contact, power supply.

So, what I mean we mean to say that if we consider the very simple system pressure tank. So, your work is basically first breakdown to all the component level and if requires sometimes to the parts level also. So, that you will understand the system and its function this breakdown is required because, you will be able to understand the function of each of the component.

And how the resultant all the components will create the that storing system, that is the

what is the sub function here storing of gas, how what is the sub function here; pumping of gas to the tank. And the overall this is basically that creating a pressure tank a tank filled with a gas of desired pressure. So, for larger system it will be large.

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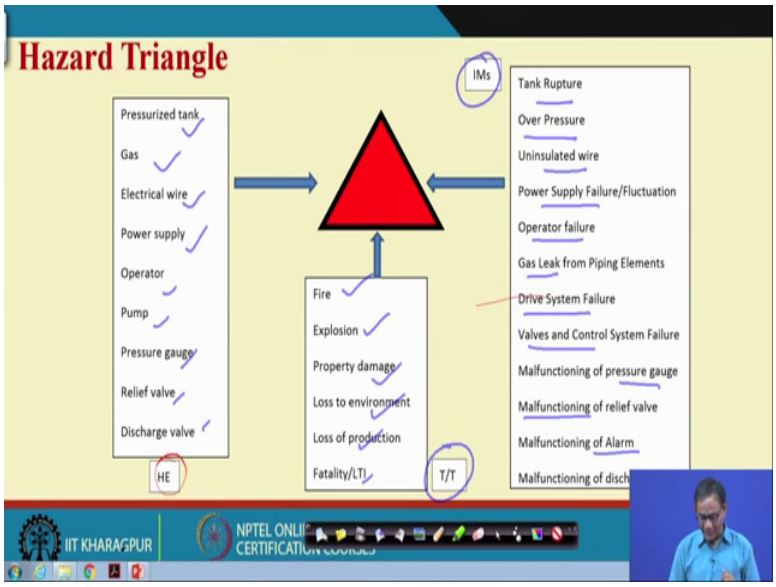

Now, hazard triangle what are the elements in hazard triangle, there will be hazardous elements or component of hazard triangle hazardous element. Then your initiating mechanism and target and threat, with reference to this pressure tank pressure tank, gas, wire, power supply, operator, pump, gauge, relief bulb, discharge bulb, all one way or other can create some can be thought of the source of hazard. So, they are either hardware or the energy sources.

So, when we talk about hazardous elements, it can be either hardware or the software or the immune wire or the energy sources or some others which are not combined there. So, for example, pressure tank is a hazard element because the tank itself can have wear and tear and finally, there can be leakage or rupture of tank also. So, that is why this is the source. Now, initiating mechanism for tank is tank rapture may take place, now over pressure inside the tank uninsulated wire, power supply, operator, failure, gas leak, drive system failure, control valve failure, malfunctioning pressure gauge, relief valve malfunction, alarm malfunction, malfunctioning of discharge valve, operators. So, many events in between that can take place, who is alone or in combination can lead to explosion, fire, property damage, loss of equipment, loss of products and fatality and

other things so these are target and threat.

So, with reference to pressure tank system this is the hazard triangle and the concept hazard triangle I have already given you and I hope that here it is you get something more means it is revisited.

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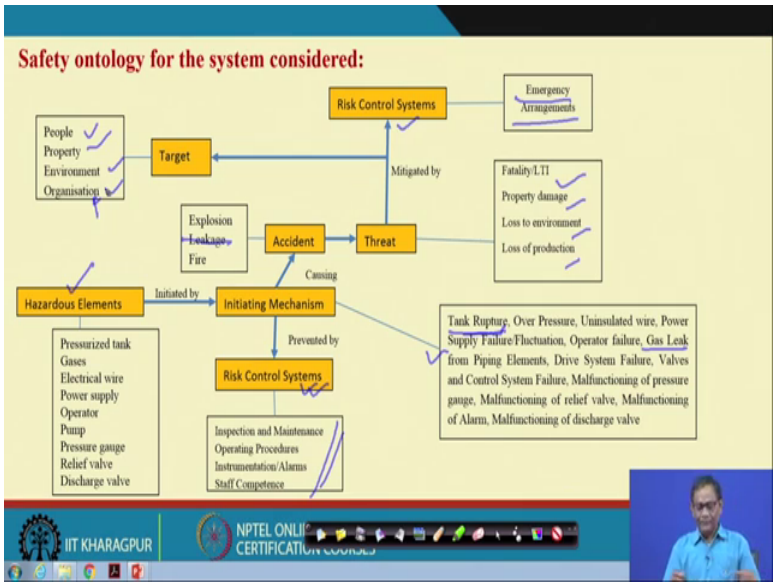

Now, then we go for the ontology part: what ontology? The same hazard triangle we have used hazard element initiated by initiating mechanism these are the initiating mechanism we have seen earlier.

And then there will be accident related to explosion, leakage, fire all those things so ok. So, we may not consider leakage may leakage may not may lead to fire and explosion. So, leakage we have written here gas leak ok. So, let explosion and fire for the time being also sometimes you may say tank rapture is the accident so that we have talk considering under explosion. So, then the accident should not happen if the initiating mechanisms and they will not align to the; that means, the accident path is not created.

So, in order to break the accident path I told that there will be discontrol system, so here inspection maintenance, operating procedure, installation alarm, start competence, this may be few of the risk control system and we should work then may be some may be the initiating mechanisms; will not ultimately occur and ultimately resulting accident will not take place ok.

So, then we if accident take place what will happen, there will be threat like fatality, property damage and all those threats are there; these threats sometimes and in hazard triangle explosion fire also we brought under targeted threat, but in the accident path we what is the additional thing we are trying to tell that, there you just find out a particular type of accident what is happening there.

So, there is no hard and fast rule that you cannot say tank rupture is an accident, if tank rupture is an accident you can write tank rapture accident, but again explosion also can be an accident that seen. So, that mean they its very flexi boundary. So, initiating mechanism the last one sometimes we are telling that the it is the accident, but whatever may be the way, but please keep in mind that that something undesired when it happen and ultimately it has threat to the target, then that is the at that one we will be talked about accident the in instead of the many hazard actuation.

And then this these threats can be minimised by another kind of risk control system, which is known as mitigated control system, here in this case we have given emergency arrangement only. And then this will lead to people, property, environment and organisation: organisation in the reputation of the organisation. From this ontology so, accident path can be created.

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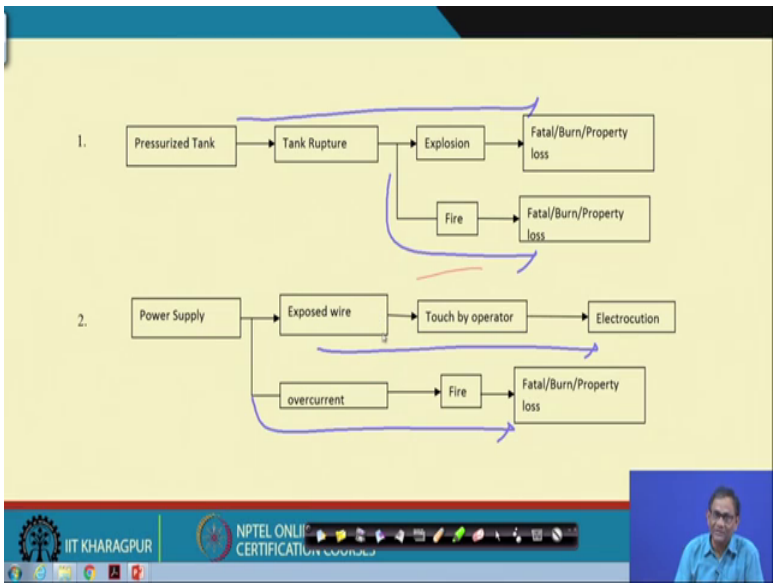

For example pressurized tank, tank rapture, explosion fire, this is one path, this is another, here power supply related one path electrocution, another path related to fatal

burning injury something like this.

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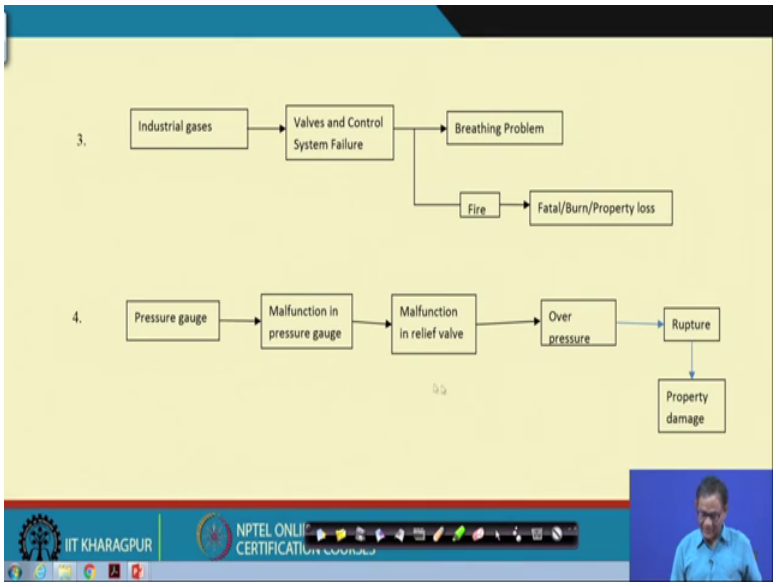

So, maybe we have missed some of the things initiating mechanism in between may you can add all those things, if you find something like this. Then gaseous bulb control and control system failure breathing problem, this gaseous may lead to ultimately fire fatal burn injury etcetera.

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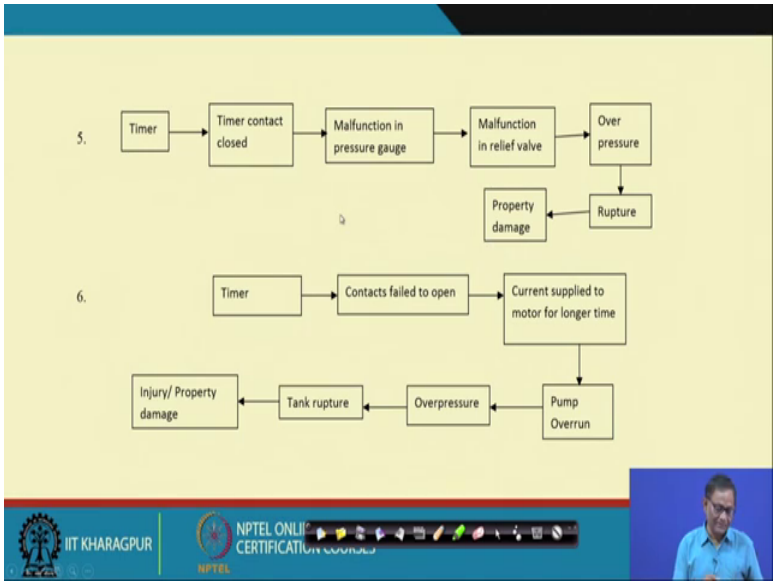

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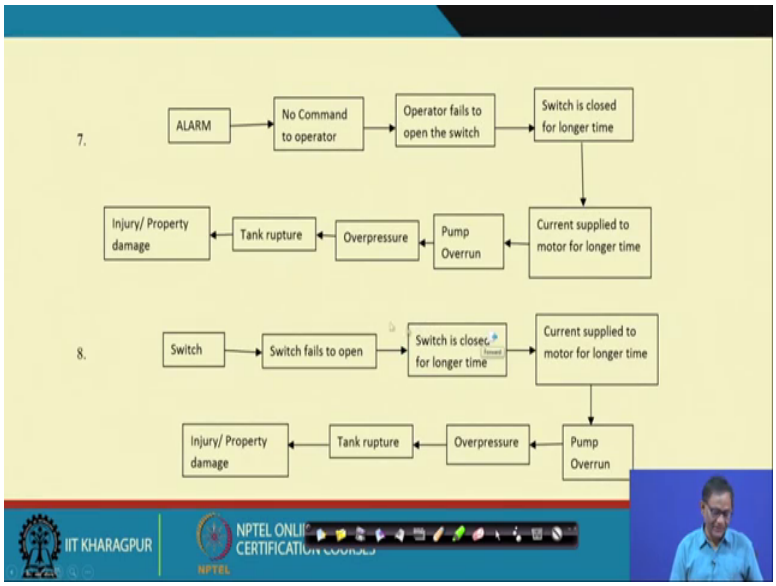

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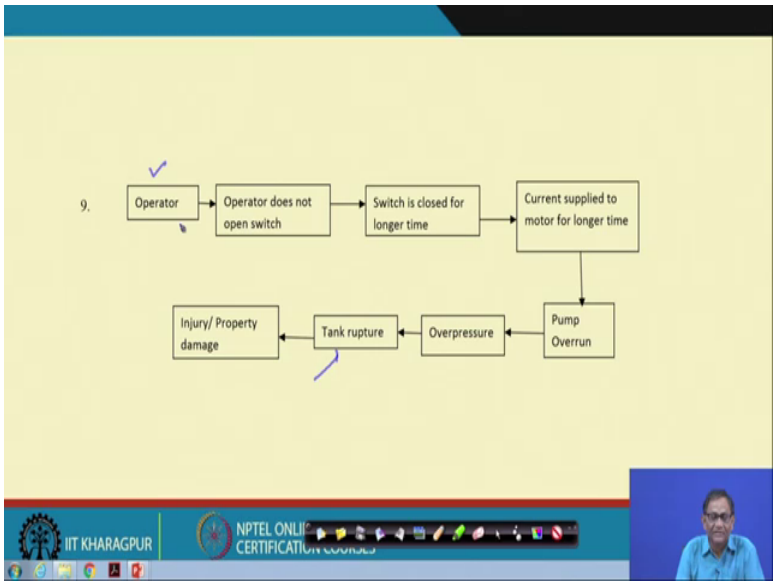

So, in this manner we created the ontology works in path 5, 6, 7, 8 now 9 operator, operator does not open switch; switch is closed for longer, time current supplied to motor for longer, time then pump overrun, pump overrun leads to over pressure, over pressure leads to tank rupture tank rupture lead to injury property damage ok.

So, you see what is happening that here the tank rupture is the accident and a property and this is the consequence, but the starting point is operator fails to do all those things once the over pressure condition has taken place and it leads to injury.

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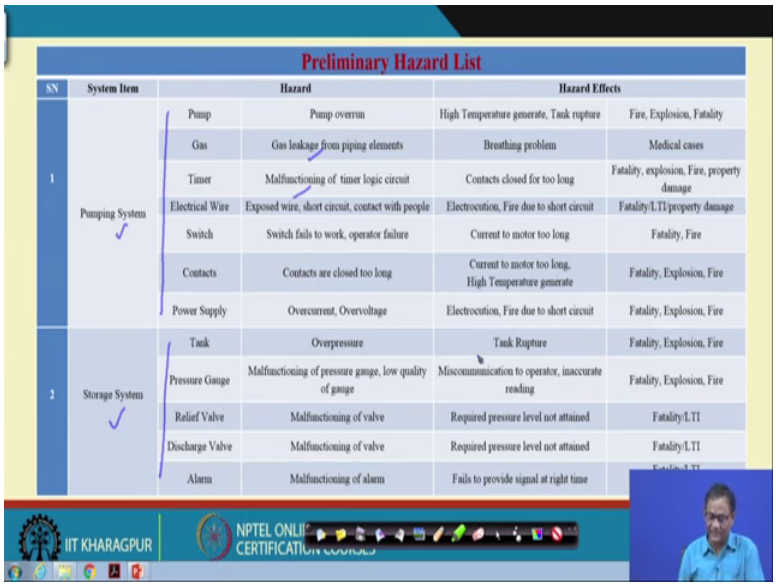

Now, for the same thing we have we have to develop the preliminary hazard list, the pumping system having this many components storage system having this many components for every component the hazard, hazard effects and means basically the hazard initiating mechanism target and threat and these are the hazard elements. So, these things we have written and we have found out several basically hazard this list pump overrun, gas leakage, malfunctioning so like this many things we have created here.

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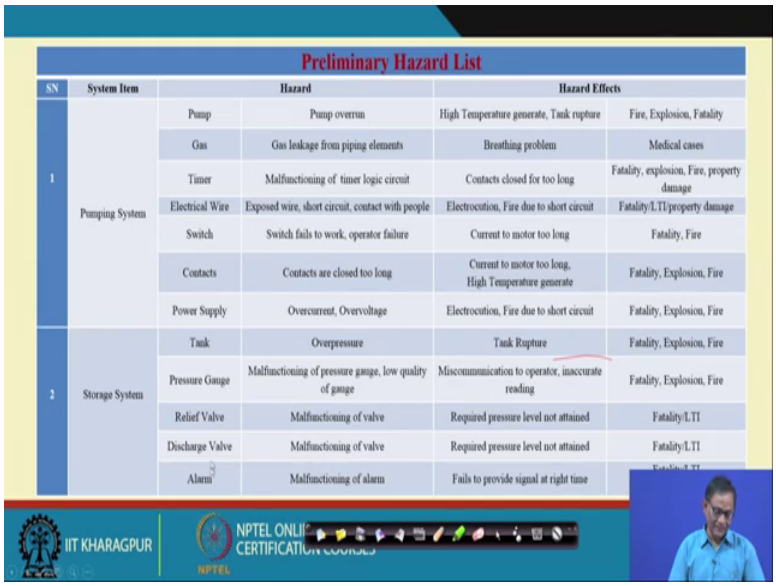

So, how many I think it is basically, so many you just see 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, we have created here. [FL] Now if you see, the preliminary hazard analysis for this 12, then IMRI and some recommended actions given and FMRI is created. So, it is not regularly maintained so that is why the effect is this, but if you regularly maintain if it will be reduced to this ok.

So, this is basically the application what I am showing so, it is a kind of revisit and similar things we have seen earlier also. So, please go through and develop your own case for PHA, PHL and other techniques.

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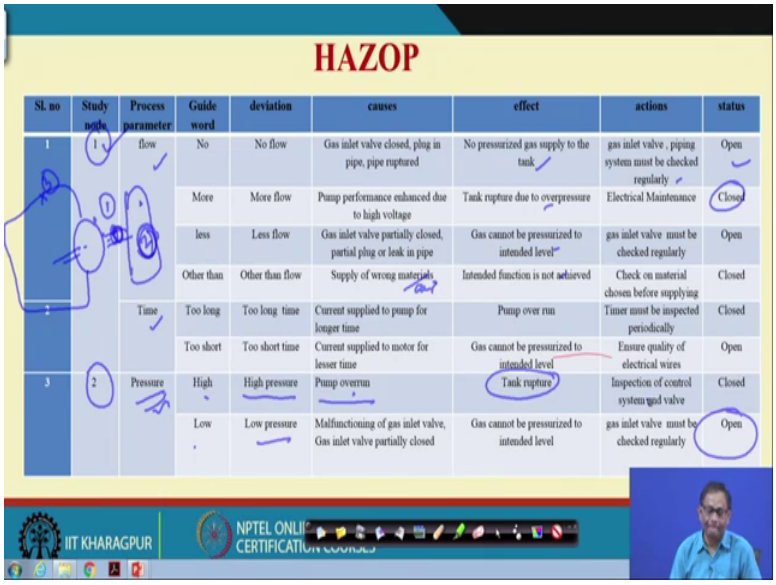

Then HAZOP or HAZOP purpose so, you have to find out the study note we have considered 2 study note, the 1st study note is the wire from pump to pressure that that is the best there is a pipe and there is pump and rest of the things like this so here one study note is taken. So, this is the 1st one and the 2nd one is the so 1 and 2, 2 different study note we have taken.

You may take some other things, but we have taken these 2 because we thought that these 2 is able to tell you most of the deviations but, there are switch another wire those deviations; also required to be found out and in that case you will basically may if you take another one in wire, then a wire is not having current then there may be problem other things that also can be taken care off. Suppose you just think of this place wire pump a from the pump that through this pipe this particular tank is filled by gas ok.

So, here flow will be important and time will be another important one, suppose flow, no flow, more flow, less flow, other than flow. Suppose no flow gas inlet one close plug in pipe, pipe rupture, more flow pump performance enhance due to high voltage [FL] less flow gas inlet valve partially closed, partially plugged or leak in pipe other than flow supply of wrong, wrong materials basically in the sense it instead of gas may be air is supplied ok.

So, then what will the, what will be the effect, what will be the actions and what is the state's open close, open close hypothetically we have written. Now this tank I think the important parameter is pressure and its guide word high means high pressure and low

pressure; high pressure what are the causes because of pump overrun, if high pressure condescended the tank rupture will take place. So, in inspection and control inspection of control system and valve; that is what is the recommendation it is already there so, low pressure malfunctioning of gas inlet valve, gas inlet valve partially closed gas cannot be pressurized to intended label given the reset time. So, gas inlet valve must be checked regularly or something like this so it is open ok.

So, what we have given then; we have given you that some it is basically revisit of the all the techniques so far you have learnt and then with reference to pressure tank example I am creating some insights into the hazard identification issues and then with reference to this example we are showing that; how it can be done and how it can you can also document the things.

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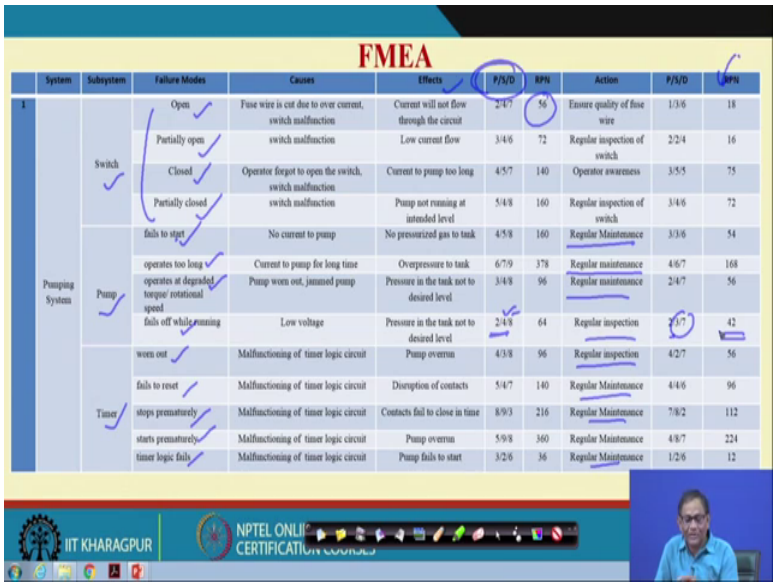

Then FMEA you see that FMEA again we says that you have to go to the sub component level switch, pump, timer, now when you talk about switch; switch failure modes maybe it is basically open all the time partially open all the time it is closed all the time partially closed fails to, [FL] this 4. Then what will happen we have written similarly pump fails to start, operates too long, operated degraded speed, fail of while, fails of while running, timer worn out, fails to restates, stop prematurely, start prematurely timer logic fails, so many things are there.

And then why it is open you have to we have written some of the causes so, you can add

to this causes, you can modify the causes also absolutely no problem, but please remember that the these are the this causes you have to the causes you have to identify.

Then what will happen if this open the effect part also then important part another important part is the finding of the probability severity and detectability we have used the tens points scale what we have given to you earlier the 10 point scale probability, severity and detestability. And then you calculate the RPN and once you create the RPN the depending on the RPN mellow you may know you may go for some kind of action or you may think that this is absolutely so maintain the Tedesco. So, sometimes we are saying the regular inspection, some of the things are already there, some of the things may not be there, but ultimately our aim here is as see we are basically saying suppose these are not done properly. So, that mean even in with regular maintenance, regular maintenance inspection and all those things if adequate lit is done so there is a chance of reduction of P S and D.

What we have assumed because, this is hypothetical example what we have assumed we have assumed that these action the these control system basically, this these control systems they are not adequately performing; it is a inspection maintenance everything is there, but they may there may be low falls.

So, then you you remember all those things to the label possible so that the effect will be more. And then what will happen the P S D either P or S or your D or all in combination that will that will be reduced for example, here P cannot be reduced, but your S and D is reduced so ultimately this is reduced. So, actually this P S D gives you very interesting idea then where the action will be taken what design and design option can be adopted so that ultimately the R P N can be minimised ok, this is what failure mode and effect analysis application.

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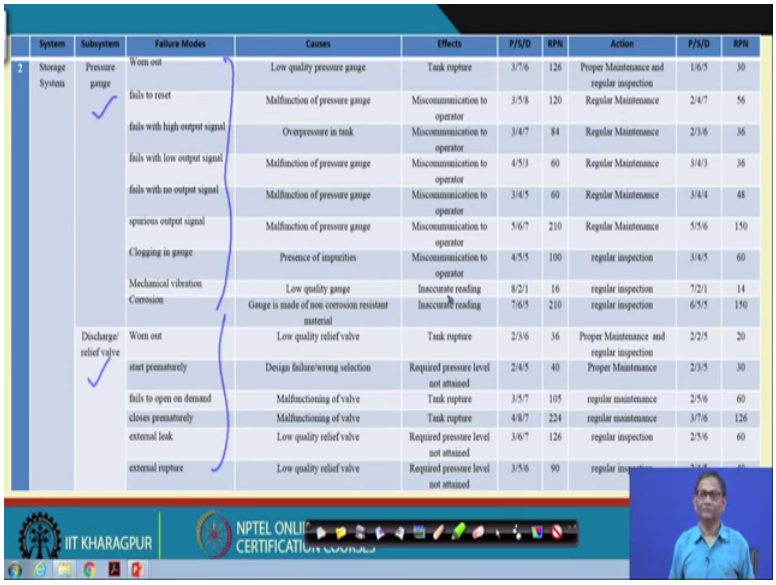

Then storage system similarly for the storage system, pressure gauge, discharge valve, so many that failure modes the causes and ultimately the concept the effects the RPN action so this is your the table, you have to prepare similar table.

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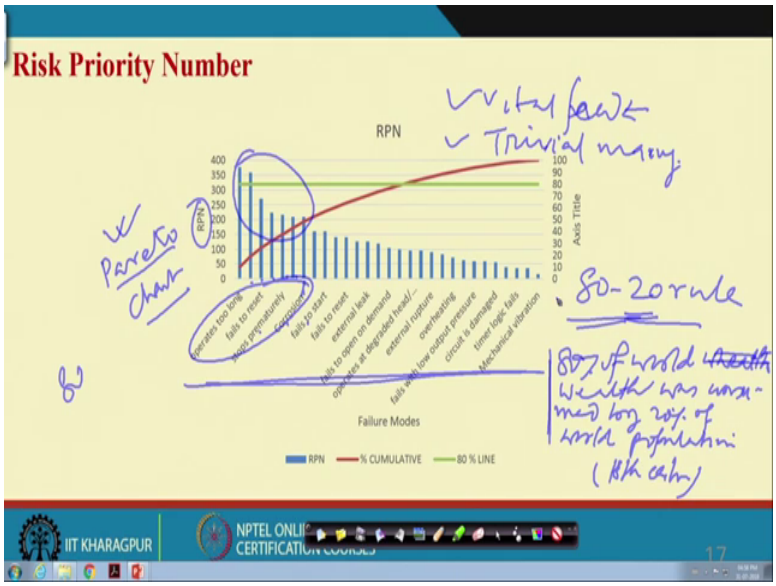

What will happen then? When you have so many; when you have so many failure modes and also you have computed their RPN you develop Pareto chart Pareto chart. So, this Pareto chart will talks about basically vital few and trivial many, vital few and trivial many, purposes to find out the vital few and trivial many maybe these are the these are the vital few or 1 2 3 4 5 6 7, 1 2 3 4 5 1 in between something not right or suppose ok, these are the vital few and these are the others are trivial many you concentrate

concentrate on vital few this is Pareto chart, this is also known as 80-20 rule.

What is 80-20 rule; 80 percent of the problems are caused by 25 percent of the or 25 percent like here 80 percent of the risk associated with 25 20 percent of the failure modes or other way actually its origin I think I have told you, other way it is basically in the 18 century Alfred Pareto observed interesting phenomena. The phenomena is this 80 percent of world wealth, wealth world wealth was consumed by consumed by 20 percent of world population in 18 century, this is in the 18 century I think so 18 century. But at the time Pareto when he was he was alive that time he observed this phenomena and then this phenomena prompted that in terms of chart we use and it has a lot of application so, this is your risk priority number and then risk priority number is used to find out the vital few failure modes.

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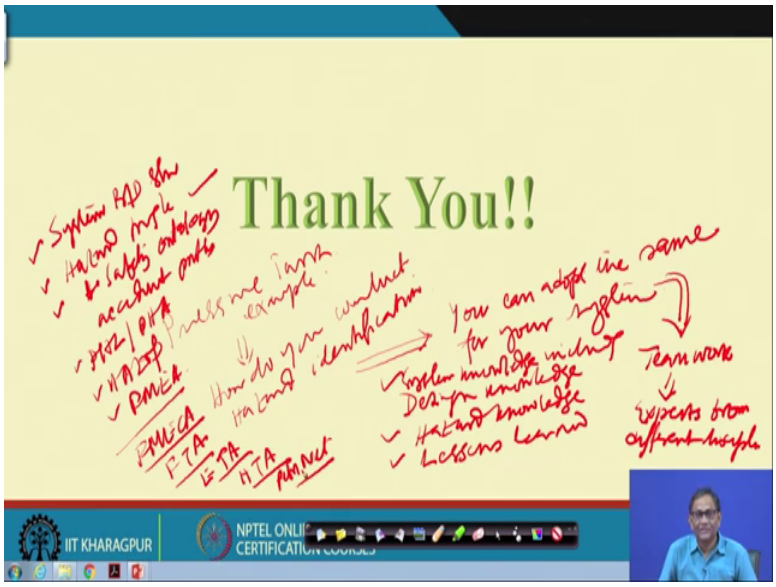

What we have discussed? We have discussed that with reference to pressure tank example; how you, how do you conduct hazard identification?

Now what is the purpose? Purpose is that you can adopt the same for your system and please understand in order to do all those things you require to have design system knowledge including design knowledge, hazard knowledge and if you have previous lessons learned. And please remember that it will not be a individual work all those things will be teamwork, team should be composed of experts from different discipline ok.

So, we have discussed system breakdown structure it is important, we have discussed hazard triangle very important, we have discussed accident path or safety ontology that is what the terminology we have used safety ontology leading to accident paths very important then PHL, PHA, HAZOP, FMEA ok.

So, there are some other technique like your FMECA Failure Mode Effect and Criticality Analysis, fault tree analysis, even tree analysis, hierarchical task analysis, Petri net many others ok. So, thank you very much, hope that you all will you will score, first of all you will understand it the next hazard identification techniques practise it and also face difficulties and you can write in the forum we will try our best to answer to your questions.

Thanks a lot, see you again.